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Structure of human eye

There are three layers of tissue in the well of eye

1. **Outer layer (fibrous)**/ sclera & cornea
2. **Middle layer (vascular**)/ choroid, ciliary body & iris
3. **Inner nervous tissue layer/** Retina

Sclera /a tough white skin of eye that covers all of the eyeball except the cornea.

Function / supports eyeball and provides attachment for muscles.

Cornea/ a clear dome over the iris, transparent covering of the front of the eye.

Function /

- Allows for the passage of light into the eye and function as a fixed lens
- Allows for the passage of light into the eye and it also focuses the light on retina.

Pupil (black hole) / the black circular in iris where light inters

Choroid

- lines the inner surface of sclera , rich in blood vessel
- light enters the eye through the pupil, stimulate the nerve endings in retina and then absorbed by choroid.

Ciliary body

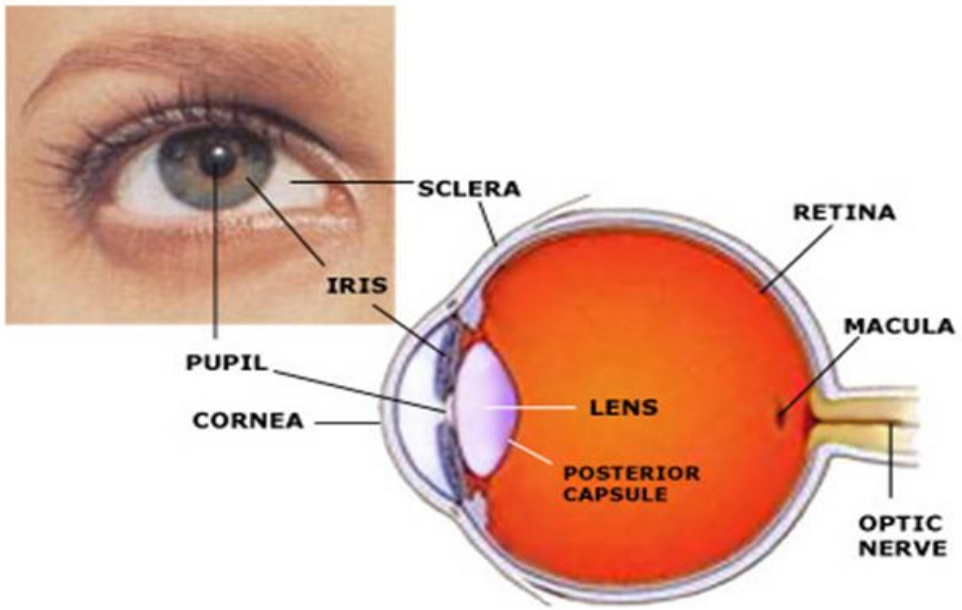
- It is the anterior continuation of the choroid
- Consist of ciliary muscle and secretory epithelial cells
- Contraction and relaxation of ciliary muscle changes the thickness of the lens

Iris / the colored part

Retina

- Inner most layer of the well of the eye
- Layer is highly sensitive to the light
- Contains light – receptive cells (rods and cones)
- Converts light to electrical signals

Optic nerve / transmits electrical signals from retina to the brain



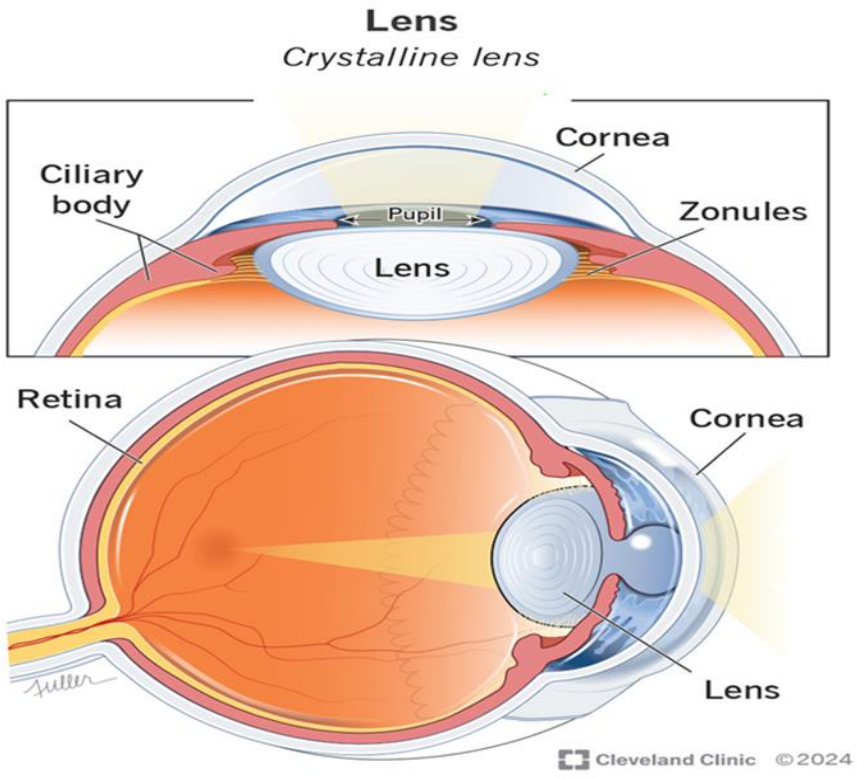
The lenses

The eye lens of humans is a transparent, a vascular, biconvex crystalline structure. Enclosed in a transparent capsule. Lies directly behind the pupil. It is responsible for focusing light on the retina.

Allow the lens to change shape depending on the amount of light that hits it so it can be properly focused.

There are two surfaces anterior and posterior. The anterior surface is an aqueous and less convex. The posterior surface is vitreous and more convex. the two surfaces meet at the equator.

Equator is almost circular and has undulated appearance.

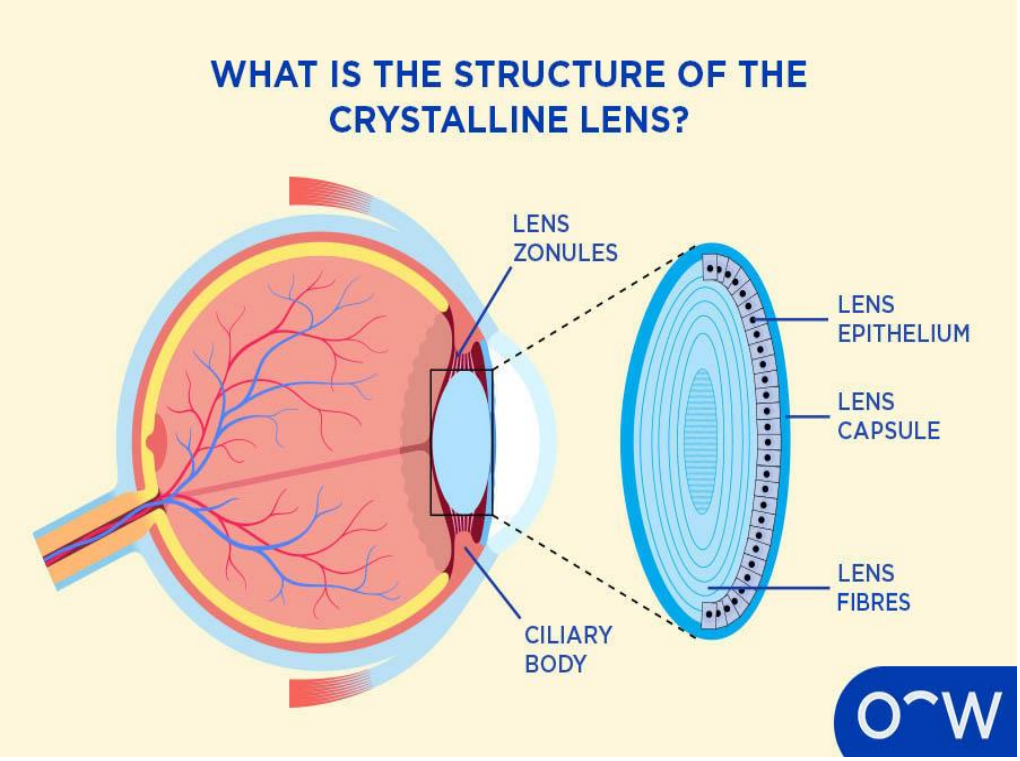


The lens consists of: -

1. **Capsules /** a bag like structure which surround the lens completely. It is a thin and transparent membrane like structure.
2. **Epithelium /** Single layer of cuboidal, confined exclusively to the anterior surface of the lens.

All metabolic, synthetic and transparent process of lens occur in this layer.

3. **Lens fibers/** which are formed from the cuboidal epithelium at the equator of the lens



Physiology of lens

Biochemical composition - lens contains

- water 65%
- protein 35%
- Glutathione, lipids, carbohydrate, amino acid, ascorbic acid and inorganic ions 1%

✓ **Water content of lens**

- Lens is relatively dehydrated organ
- Dehydration is maintained by active Na- pump within cell membrane of epithelium and each lens fiber.
- 80% of water is free and rest 20% bound
- In normal lens there is no significant alteration in hydration with age.

Proteins /

- Lens contain soluble and insoluble **proteins** (albuminoid) and other proteins such as glycoprotein, lipoprotein and phosphoprotein.

- ✓ **Amino acid/**
  - Lens contain amino acid actively transported from aqueous humor to lens.
  - Amino acid concentration of lens is not affected by ageing
- ✓ **carbohydrates** / Lens contains carbohydrates such as glucose, fructose and glycogen.
- ✓ **Lipids**
  - Total lipid of human lens amount to about 2.5% of wet weight
  - Main substances are cholesterol and various phospholipids
  - 65% of lipids are bound to protein.

Metabolic activities of lens

- ✓ **Glucose metabolism**
  - Lens require energy in form ATP for its various metabolic activities
  - This energy achieved by glucose metabolism
  - 10-20% of ATP used in protein synthesis
  - Rest used for transport of ions, amino acid, maintains of lens dehydration and transparency
- ✓ **Protein metabolism**
  - **Synthesis**
    - Peptides formed from amino acids with requires ATP and RNA template
    - Rate of protein synthesis is slow in nucleus than other part of lens
  - **Break down**
    - Protein catalyzed by enzyme peptidases and proteases
    - Normally the process of autolysis is inhibited

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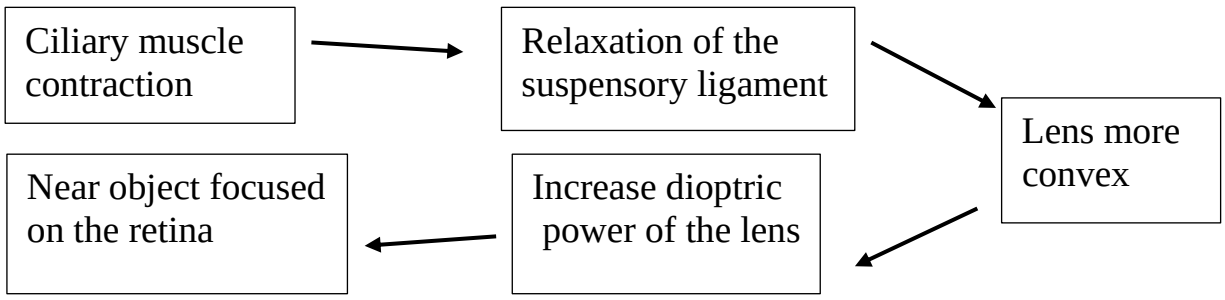
Accommodation

Accommodation / It is the process through which the eye changes the refractive power by altering the shape of lens in order to focus objects at different distances to sees clear images.

Mechanism of accommodation

Accommodation is achieved by a change in the shape of lens as below:



Near point and Far point

1. **Near point/** The closest point from which small objects can be clearly seen, is called near point or punctum proximum
2. **Far point** / the distal point or Pontum Remoteum.

The far point and the point near the eye vary with fixed refraction of the eye:

1. The lens is flattened for distant objects.
2. The lens is rounded for near objects

Accommodation Reflex

Focusing at near object (increased anterior surface curvature of lens by ciliary muscles contraction —> relaxed ligaments & increased anterior surface curvature of lens)

Distant Vision:

1. Ciliary Muscle Relaxed

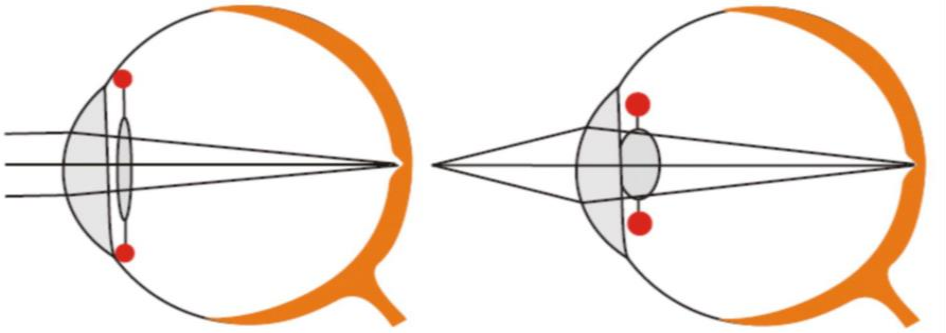
2. Suspensory Ligaments Under Tension
3. Lens is Flattened

Focus on **Distant Objects**

Near vision

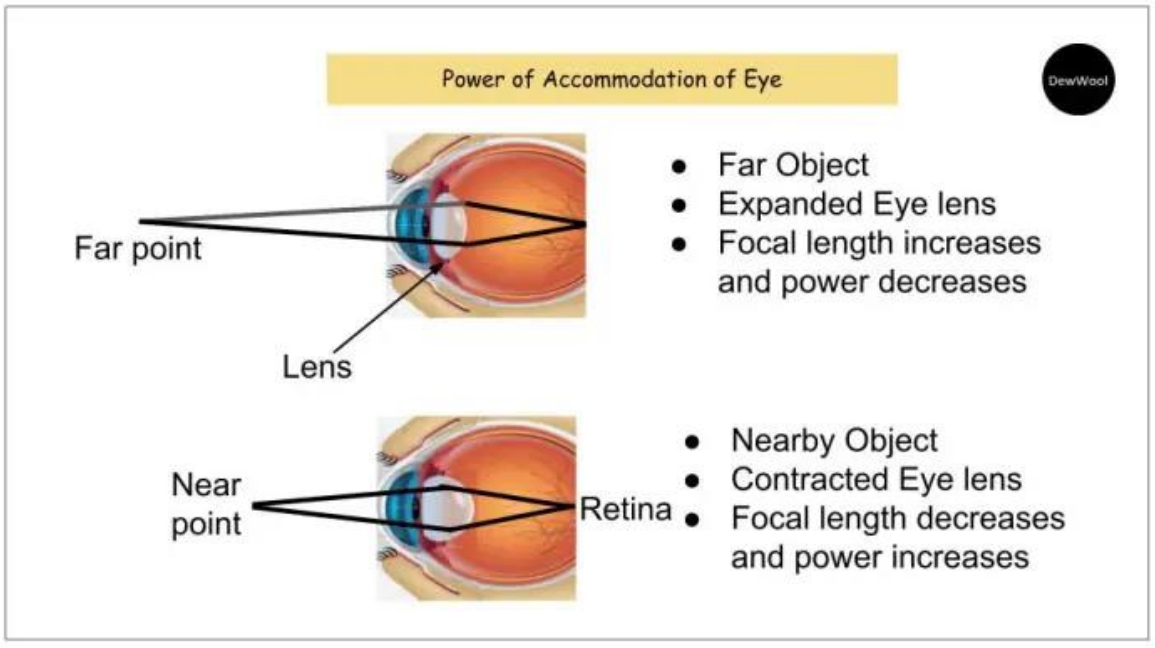
1. Ciliary Muscle Contracts
2. Reduced Tension on Suspensory Ligaments
3. Lens becomes Round

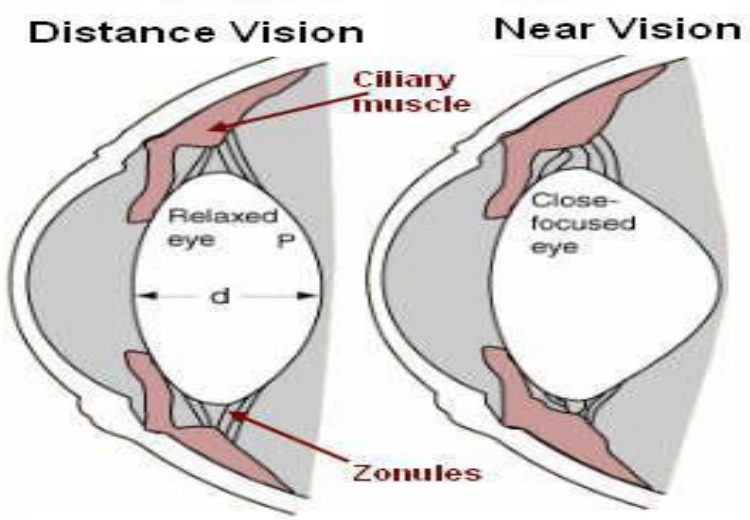
Focus on **Near Objects**



When the ciliary muscles are **relaxed** the lens is flat and distant objects are focussed onto the retina

When the ciliary muscles are **contracted**, the lens becomes more round and a close object is focussed onto the retina





For near vision, the ciliary muscles contracts and the central lens thickness increases to increase its power.

Range and capacity of accommodation

Accommodation range/ distance between the near and far points

Accommodation capacity/ The difference between refractive power needed to focus on the near point (P) and far point (R) is called amplitude accommodation (A).

A=P-R

Accommodation anomaly

Anomalies of accommodation include:

- ❖ Accommodation paralysis
- ❖ Accommodation spasm
- ❖ Presbyopia
- ❖ Insufficiency of accommodation

Accommodation paralysis

Also known as cycloplegia refers to the complete absence of accommodation

Causes

1. **Drugs /** Drug-induced cycloplegia results from the effects of atropine and homatropine
2. **Internal ophthalmoplegia**/ paralysis of the ciliary muscles and myosis may result from neuritis associated with diphtheria, Syphilis, diabetes, alcoholism, cerebrovascular or meningeal diseases

Symptoms

1. Blurring of near vision
2. Abnormal receding of the proximal point and marked decrease in range of motion.
3. Photophobia (glare) due to dilated pupils (mydriasis).

Treatment

1. Self-recovery occurs in drug-induced cycloplegia.
2. Dark glasses are effective in reducing glare.
3. Convex lenses may be prescribed for near vision in case of paralysis

Accommodation spasm

Accommodation spasm indicates an abnormally large effort

Causes

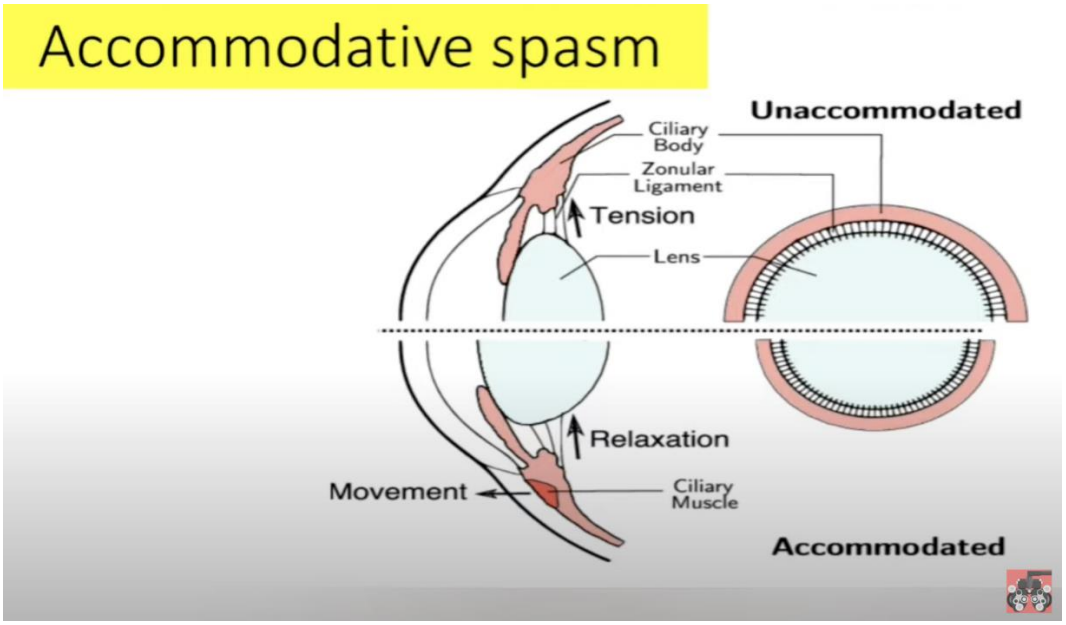
1. Drug-induced spasm of accommodation like use of strong miotics such as echothiophate
2. Spontaneous accommodation spasm is found in children who are trying to compensate for a refractive abnormality that impairs their vision

Symptoms

1. Defective vision due to induced myopia.
2. Asthenic symptoms are more pronounced than visual symptoms

Treatment

1. Relax the ciliary muscle with atropine for several weeks and prevent near work.
2. Correcting the associated causative factors and preventing their recurrence
3. Providing support and psychological treatment if necessary.



Presbyopia

(eye sight of old age) is not an error of refraction but a condition of physiological insufficiency of accommodation leading to a progressive fall in near vision.

Causes: -

Age -related changes in the lens which include:

a. Progressive increase in size and hardness (sclerosis) of lens substance
b. Decrease in the elasticity of lens capsule

Premature presbyopia which includes:

a. Premature sclerosis of the crystalline lens.
b. General debility causing presenile weakness or ciliary muscle
c. Chronic simple glaucoma.

Symptoms

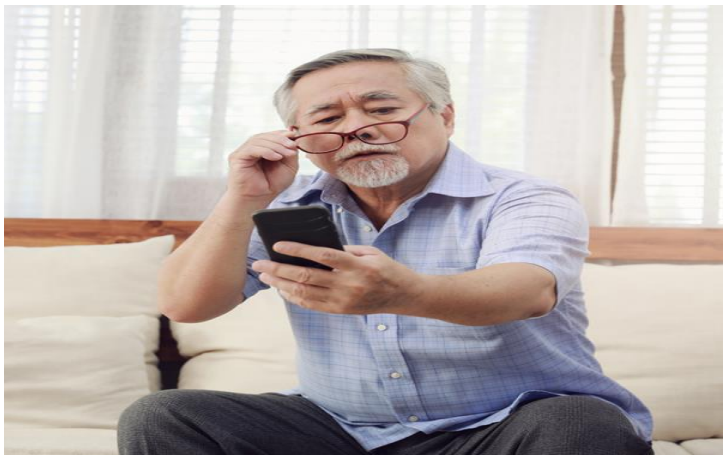
1. Difficulty in near vision/ patients usually have difficulty reading small prints in the evening, in dim light and difficulty inserting the needle.
2. Symptoms of asthenia also appear due to fatigue of the ciliary muscle complained after reading or doing any near work.

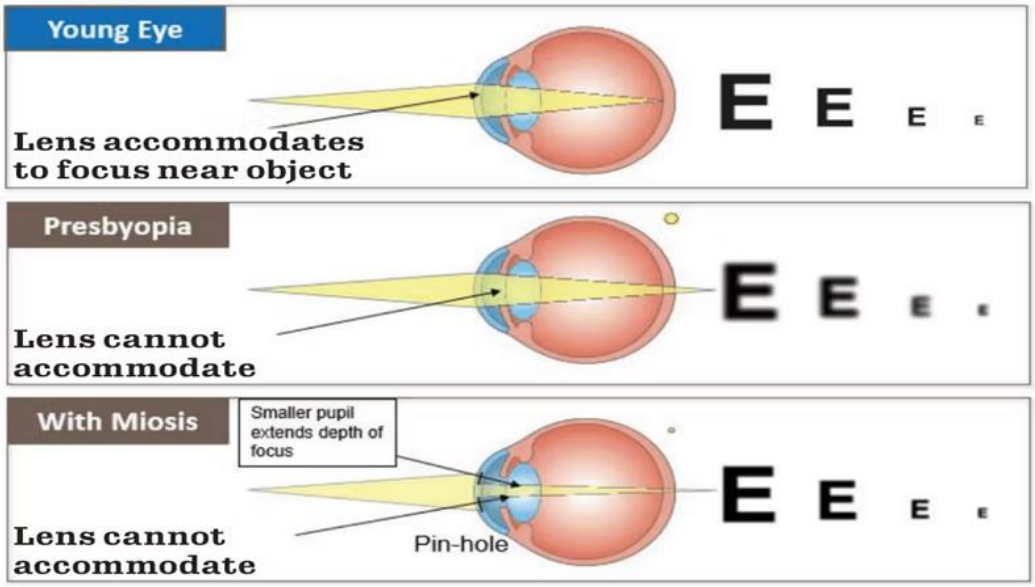
Treatment

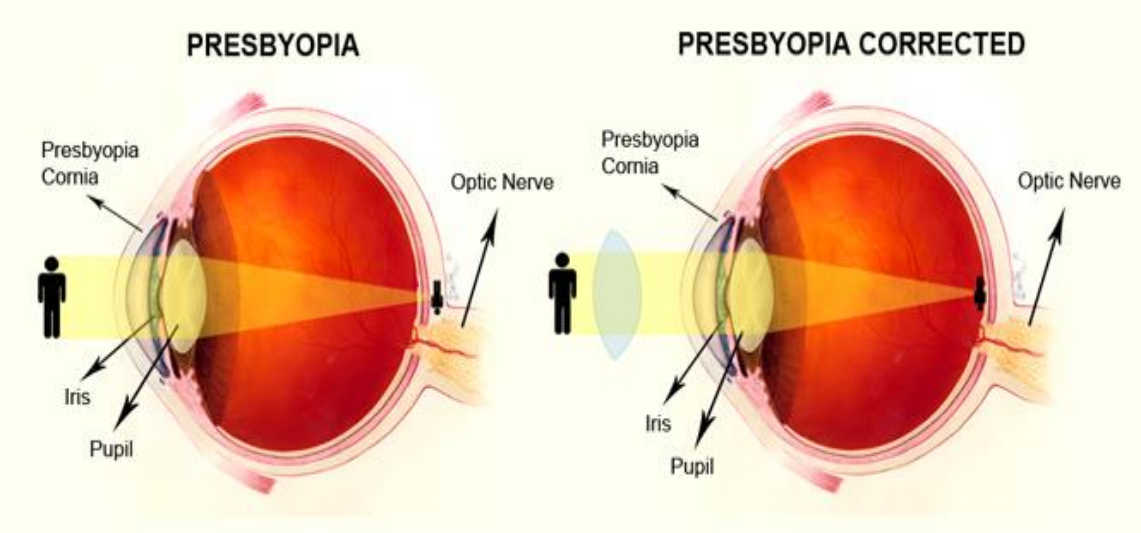
1. Visual therapy/ Treatment for presbyopia is prescription

Convex glasses are suitable for close work

2. Surgical treatment







Insufficiency of accommodation

Used when the accommodative power is significantly less than the normal physiological limits for the patient's age.

Causes

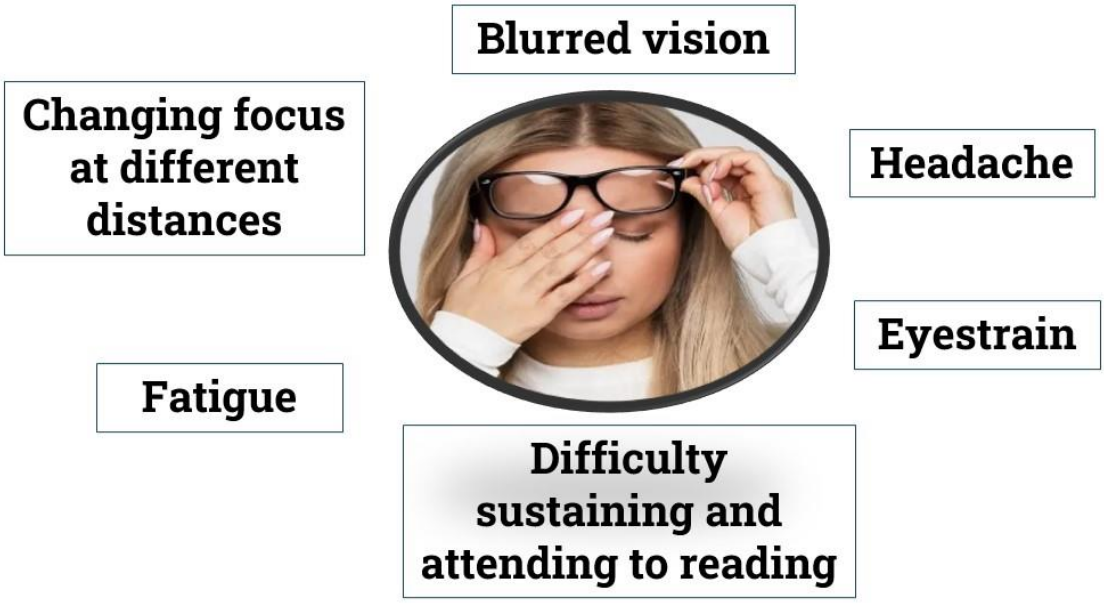
1. Weakness of ciliary muscle due to systemic causes of muscle fatigue such as disease, anemia, toxemia, malnutrition, diabetes mellitus, pregnancy, stress
2. Premature sclerosis of lens.

Symptoms

All the symptoms of presbyopia are present, but the symptoms of asthenia are more severe protruding from blurred vision.

Treatment

1. Treating the underlying cause is essential.
2. Near vision glasses have a weaker convex lens shape.
3. Accommodation exercises aid in recovery.

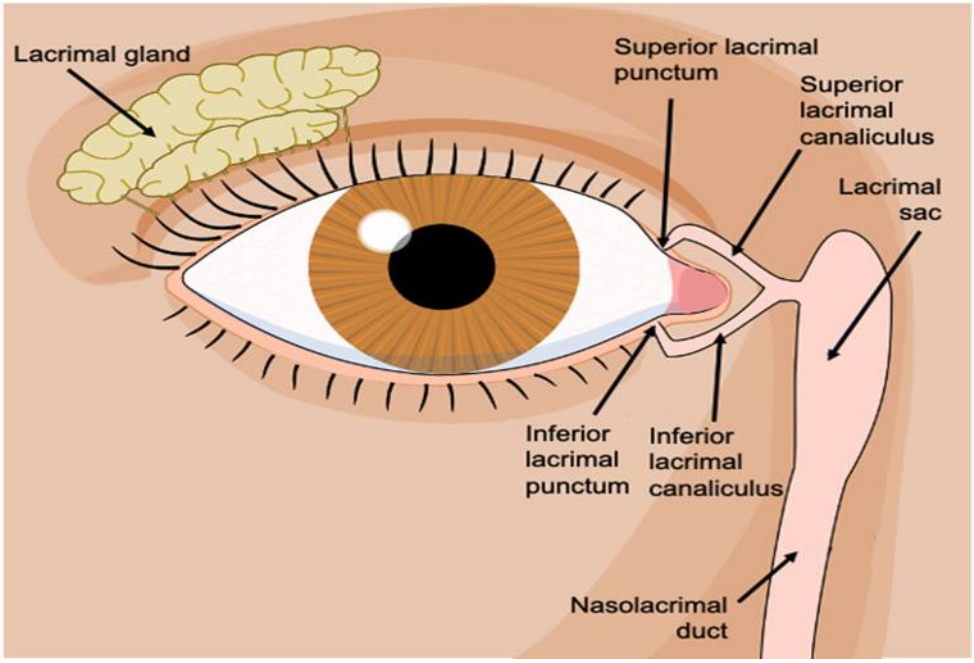


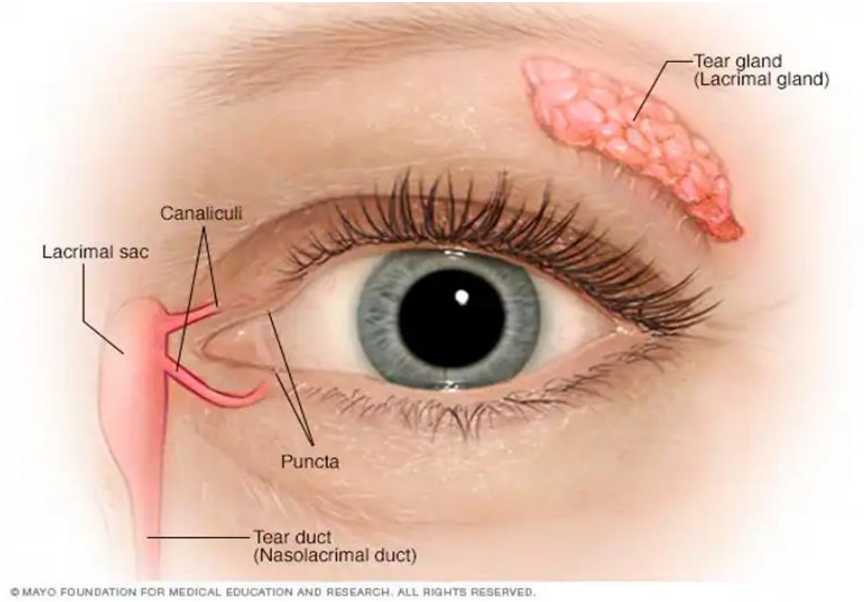
Lacrimal system and Tears

Lacrimal system / is the physiological system containing the orbital structures for tear production and drainage.

The lacrimal system comprises

1. **Formation of tears**
    a. Main lacrimal gland
    b. Accessory lacrimal gland
2. **Transport of tears** / by lacrimal passage- include
    a. Puncta
    b. Canaliculi
    c. lacrimal sac
    d. nasolacrimal duct.





Lacrimal glands

- These are serous glands situated at the upper and outer angle of the orbit, in a depression known as the fossa for the lacrimal gland.
- Gland is divided into two parts: - the upper orbital part and the lower palpebral part.
- The glands secrete tears composed of water, salts, and lysozyme (a bactericidal enzyme)

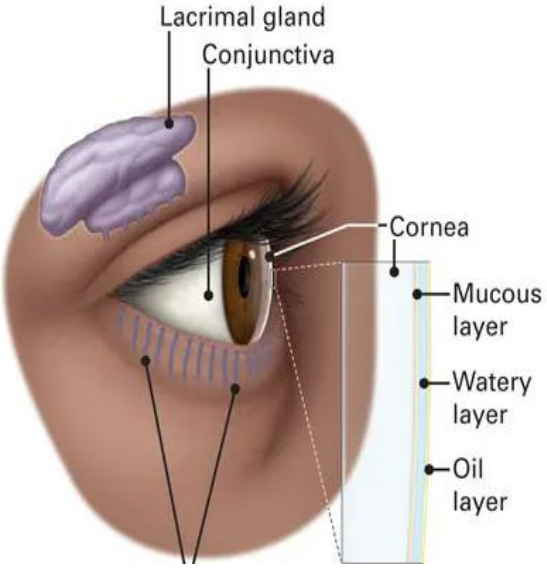
Accessory lacrimal gland / These are very small glands of exactly the same structure as the lacrimal gland

- **Glands of Krause /** lying beneath the palpebral conjunctiva between fornix and edge of tarsus
- **Glands of wolfring** / these are few in number, present near the upper border of the superior tarsal plate and a long the lower border of inferior tarsus.

All lacrimal glands – serous similar to salivary glands

Tear film / Fluid covering the cornea and called it precorneal film. Consist of three layers: -

- Mucous layer
- Aqueous (watery) layer
- Lipid or oil layer



Mucous layer / consist of mucin secreted by conjunctival goblet cells and glands of Manz. It converts the hydrophobic corneal surface into hydrophilic one.

Aqueous (watery) layer /

- The bulk of tear film is formed by this intermediate layer which consist of tears secreted by the main and accessory lacrimal gland.
- The tears mainly comprise of water and small quantities of solutes such as sodium chloride, sugars, urea and protein
- Therefore, it is alkaline and salty in taste, it's also containing antibacterial substances like lysozyme.

Lipid or oil layer

This is the outermost and thinnest layer of tear film formed at air-tear interface, this layer prevents the overflow of tears, retards their evaporation and lubricates the eyelids.

Functions of tear film

1. Keeps moist the cornea and conjunctiva
2. Provides oxygen to the corneal epithelium
3. Washes away debris and noxious irritants
4. Prevents infections due to presence of anti-bacterial substances
5. Facilitates movements of the lids over the globe

Secretion of tears

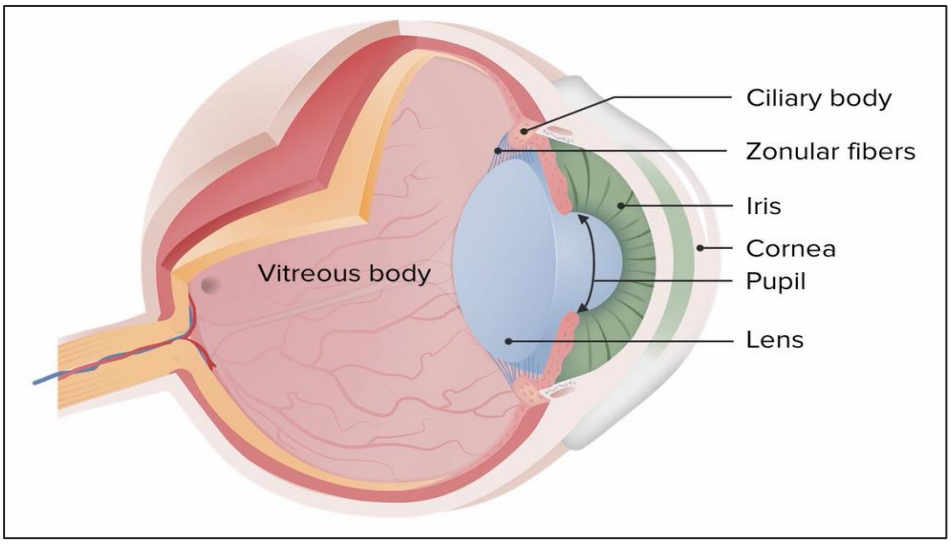
Two types: basal and reflex secretion

1. **Basal secretion** / Tears are secreted through out the day by accessory lacrimal gland basal secretion.
2. **Reflex tears**
   - Caused due to irritation of foreign particles or an external stimulus.
   - They are secreted by main lacrimal glands
   - The reflex tears attempt to wash out irritants that may have com in contact with the eye.

The vitreous

General features of the vitreous

1. Vitreous humor is an inert, transparent, colorless, jelly-like, hydrophilic gel, that serves the optical functions and also acts as important supporting structures for the eyeball. Fills the eyeball behind the lens.
2. Vitreous cavity is bounded anteriorly by lens and ciliary body. And posteriorly by retina.
3. Vitreous is more viscous than water but let's light through, and Allows light to reach retina
4. Pathway for nutrients to reach the lens and retina
5. Contained in a protective layer called the vitreous membrane
6. Vitreous humor is responsible for about 80% of the volume of eye
7. Vitreous humor contains salts, sugars, proteins and collagen in addition to water, there are also phagocytes or cells that help keep eye clean



Structure of the vitreous

The vitreous is the largest and simplest connective tissue present as single piece in the human body. Divided into three layers

1. Hayloid layer or membrane
2. Cortical vitreous
3. Medullary vitreous

Hayloid layer or membrane

It is not a true membrane but the outermost surface of vitreous, it has a structure of connective tissue and shows fibrils which run parallel with the surface. It has two layers: -

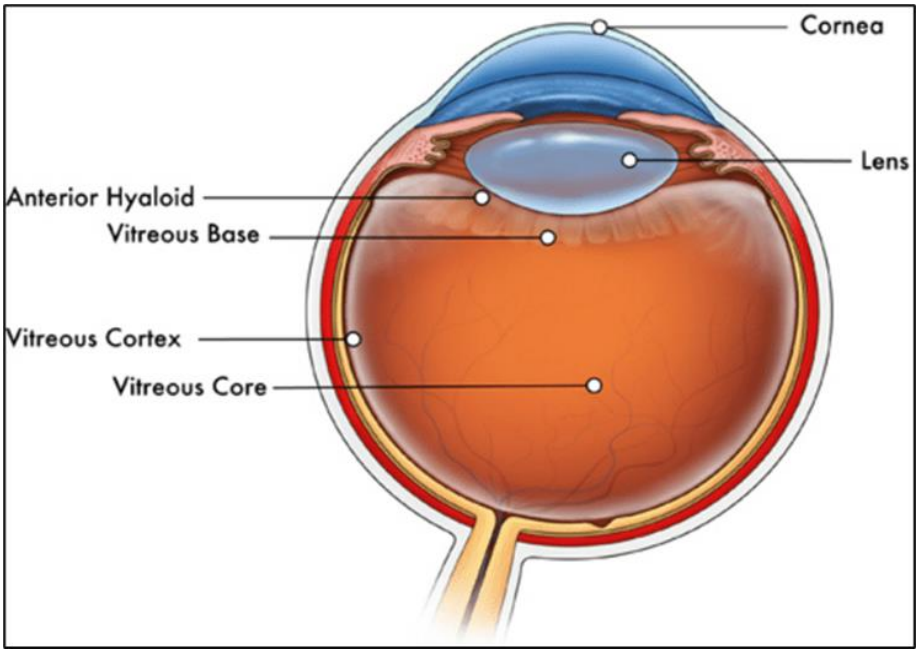
a. **Anterior hayloid membrane** / lies in contact with pars plana, ciliary process, ciliary zonules and posterior lens capsule.
b. **Posterior hayloid membrane** / extends from the vitreous base to optic base.

Cortical vitreous

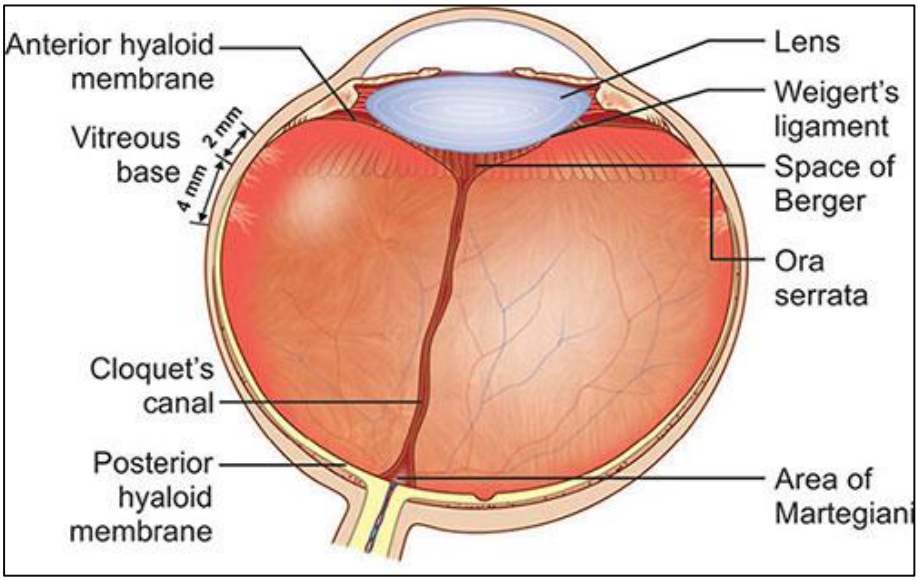
Peripheral zone, It is more condensed fibrillar vitreous, Lies adjacent to the retina posteriorly and to the lens, ciliary body and zonules anteriorly. Contain two types of collagen fibrils interspersed with the sodium hyaluronate mucopolysaccharides molecules, which provides a viscosity and elasticity.

Medullary vitreous

Majority of the vitreous body is formed by the central medullary vitreous. Similar to the cortical vitreous except it is a less fibrillar structure



- The anterior cortex consists of condensation of collagenous fibers that attach to the posterior surface of capsule of lens forming **Wiegers ligament or called hayloideocapsular ligament**
- The space between lens and anterior vitreous (anterior hyaloid) which is bordered by Wiegers ligament is called the **Bergers space**
- **Cloquet's canal /** central vitreous is traversed by a canal is known as Cloquet's or hyaloid canal
- **Vitreous base/** the place is strongest adhesion of vitreous



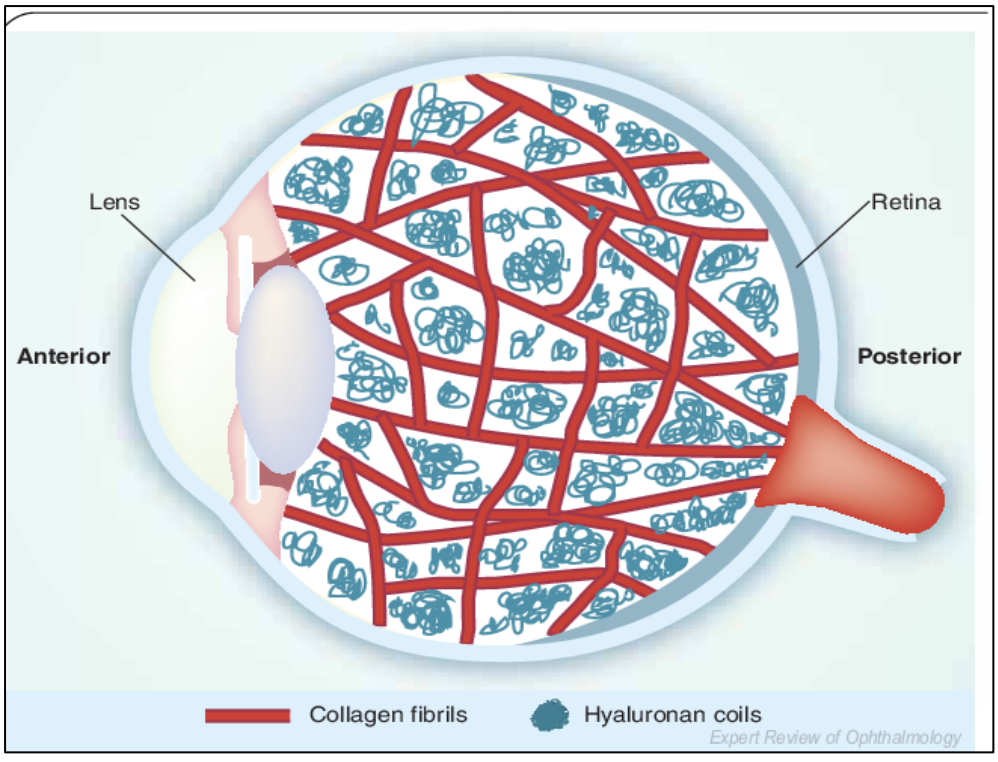
Biochemical properties of vitreous

Vitreous consists of three major structures: **Water, Collagen fibers** and **GAGs**

- The vitreous contains more than 99% of water.
- The vitreous exists as a gel -like structure due to the arrangement of long, collagen fibrils which are suspended in a network of hyaluronic acid (HA)
- **GAGs**/ Glycosaminoglycan - unbranched molecule twisted network. stabilizing the gel state of eye vitreous humour

Cells: normally found as **haylocytes** (function as phagocytes) and **fibrocytes** (produce collagen)

Bicarbonate, Proteins, lipids, and Amino acids.



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Aging of vitreous support function to retina

Function of the Vitreous:

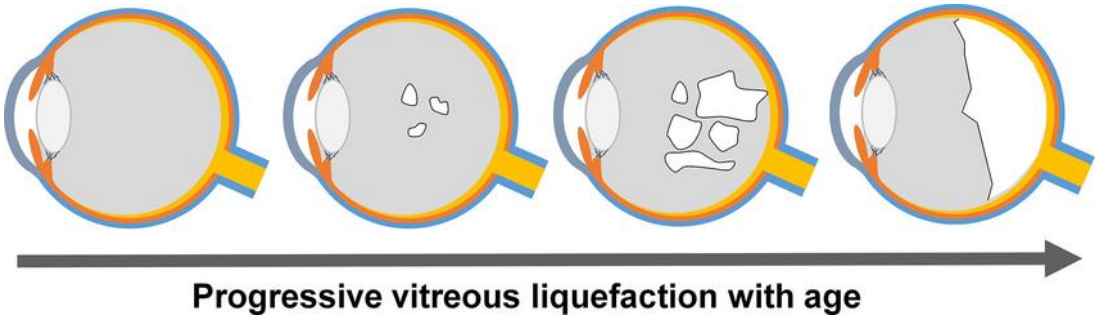
The vitreous performs several important functions, including:

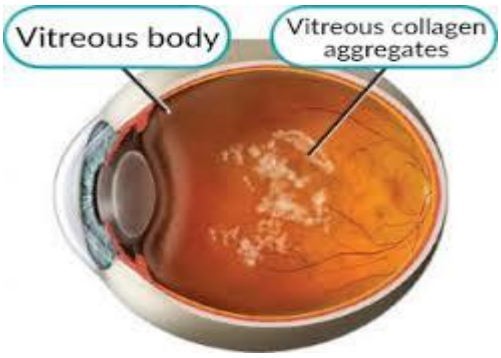
1. **Structural support**: The vitreous body helps maintain the shape of the eye and provides structural support, protect retina during eye movements.
2. **Optical clarity**: The gel-like consistency of the vitreous allows light to pass through to the retina without significant refraction or scattering.
3. **Nutrient transport**: It helps to transport nutrients to the lens and retina, especially in areas without blood vessels
4. **Shock absorption**: It acts as a barrier to protect the retina from mechanical damage and impacts.

Aging of the Vitreous:

As the eye ages, the vitreous undergoes various changes that can affect its function, especially in relation to its support role to the retina:

1. **Liquefaction of the vitreous**: As a person ages, the vitreous humor gradually becomes less gel-like and more liquid. This process is known as vitreous syneresis.
    - The collagen fibrils that form the structure of the vitreous begin to aggregate and condense, leaving spaces filled with fluid.
    - This can cause the vitreous to shrink and detach from its normal position, potentially leading to complications.

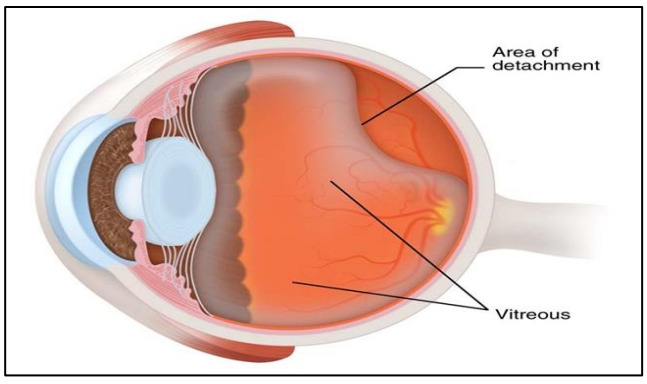


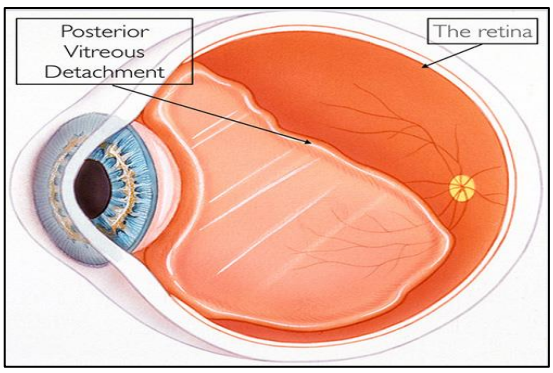


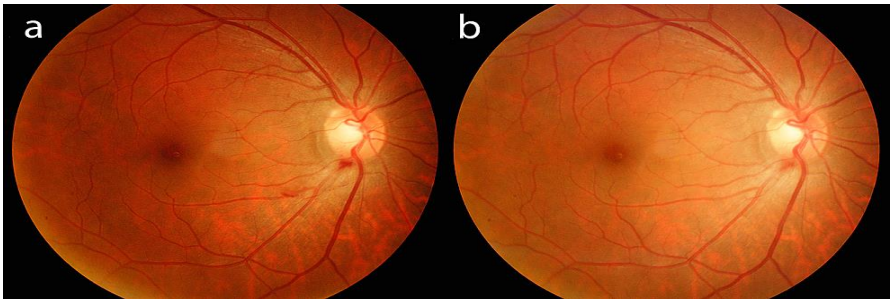
2. Vitreous detachment (Posterior Vitreous Detachment - PVD):

Posterior Vitreous Detachment (PVD) / The vitreous separates from the retina due to the natural aging process.

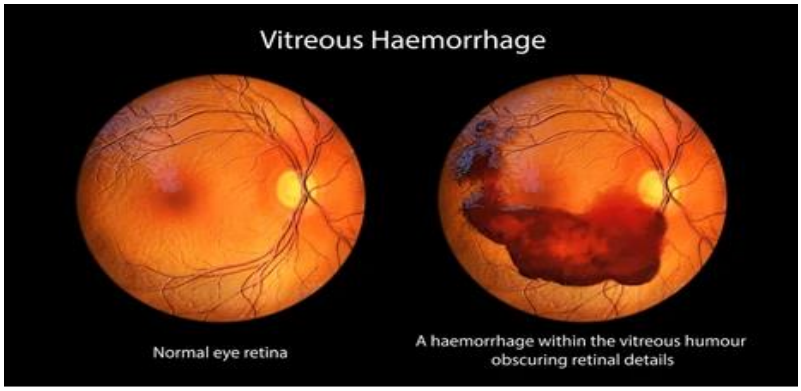
- It is most common in older adults affecting about 65% of individuals over 65 years. Often linked to eye injuries or ocular inflammation
- Although PVD is often asymptomatic, it can lead to visual disturbances like flashes of light or floaters as the vitreous moves within the eye.





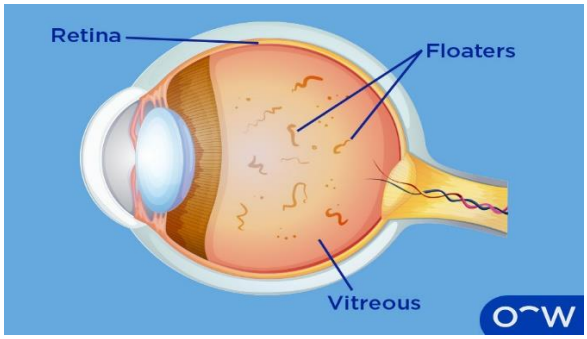


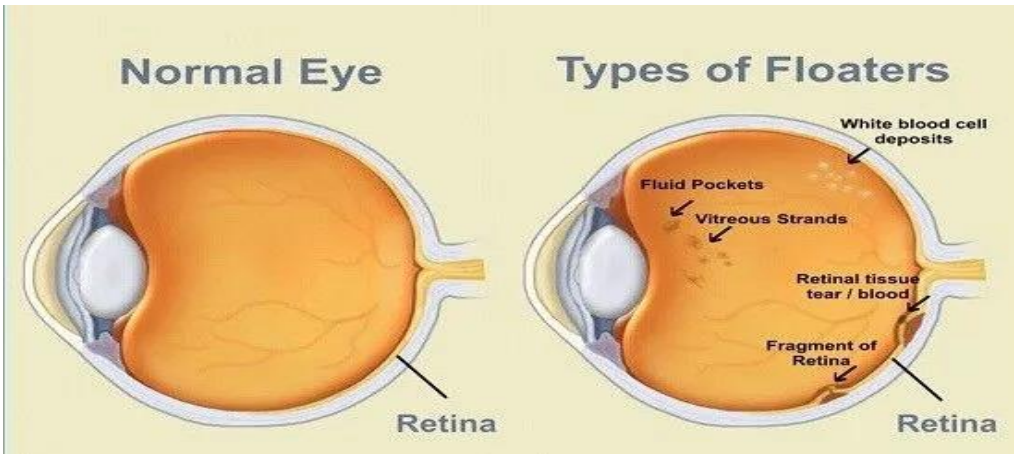
3. **Vitreous hemorrhage** / occurs when there is blood (or black spots) in the vitreous cavity. The three causes of bleeding in the vitreous are abnormal vessels which are prone to bleeding, normal vessels which rupture due to stress and extension of blood from an adjacent source such as tumors, diabetes mellitus, hypertension



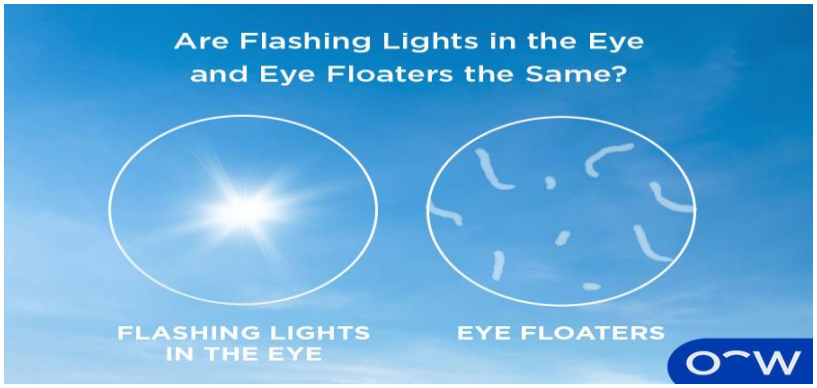
Clinical Manifestations of Vitreous Aging:

Floaters: As the vitreous liquefies, small clumps of collagen fibers can form, appearing as floaters in the visual field. These are usually more clearly in older individuals.





- **Flashes of Light**: When the vitreous pulls away from the retina, it can cause flashes of light (photopsia), especially in peripheral vision. This can be alarming to patients, but it's typically not harmful unless it is associated with a retinal tear or detachment.
- **Decreased Visual Acuity**: As the vitreous becomes less clear and undergoes changes such as traction or detachment, visual acuity can be affected, leading to blurry or distorted vision.



Take care of the vitreous humor

1. **Regular eye tests:** regular eye tests are very important in taking care of eye health, including the health of vitreous humour. Eye tests allow optometrists to monitor the health of your eye and detect eye problems.
2. **Eat a healthy diet:** A healthy and balanced diet is beneficial for overall eye health including for the vitreous humour. By eating well, and which helps to boost immunity and health.
3. **Stop smoking:** Smoking is very detrimental to a person's eye health as it has been shown to cause damage to the macula and the retina. Smoking is also linked to an increased risk of age-related degeneration

Management of Vitreous Aging:

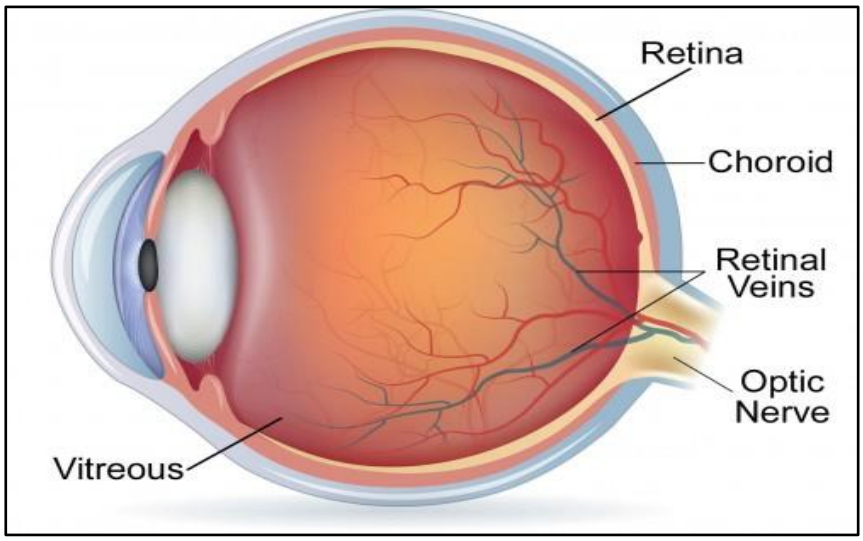
- **Observation**: Most cases of vitreous aging, such as posterior vitreous detachment (PVD), do not require treatment and are simply monitored for signs of retinal complications.
- **Laser Treatment**: For patients with retinal tears caused by vitreous traction, laser photocoagulation may be used to seal the tear and prevent further progression to retinal detachment.
- **Surgical Intervention**: In cases of macular holes, severe vitreomacular traction, or retinal detachment, surgical intervention, such as vitrectomy (removal of the vitreous), may be necessary to prevent vision loss

Retina histology & function

The retina is a light -sensitive layer at the back of the eyeball that is play a role in vision or it is photosensitive layer of the eye it converts light energy to electrical signals that the brain can interpret as image.

Consisting of two main layers: Outer retinal pigmented epithelium / its outer surface and is contact with the choroid. and **Inner sensory retina /** its inner surface is in contact with the vitreous body. With a potential space called subretinal space between them.

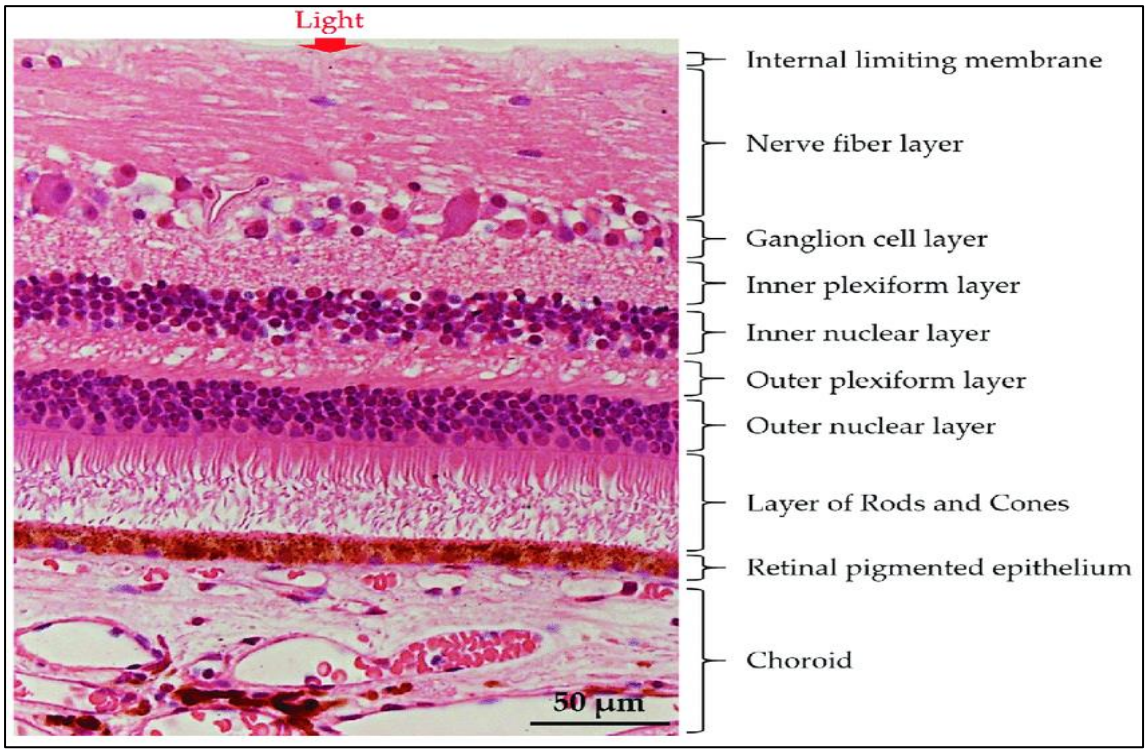
- It is lies between the choroid and the vitreous
- The anterior pigment of epithelium of the iris continues as the outer pigment epithelium of the ciliary body and later forms the retinal pigment epithelium



Retina consists of 10 distinct layers each with specific cells that contribute to visual processing, from outside inwards of the following layers: -

1. Retinal pigment epithelium (RPE)
2. Layers of the rods and cones (photoreceptor layer)
3. Outer / external limiting membrane
4. Outer nuclear layer
5. Outer plexiform layer

6. Inner nuclear layer
7. Inner plexiform layer
8. Ganglion cell layer
9. Nerve fiber layer
10. Internal limiting membrane



Types of Cells in the Retina

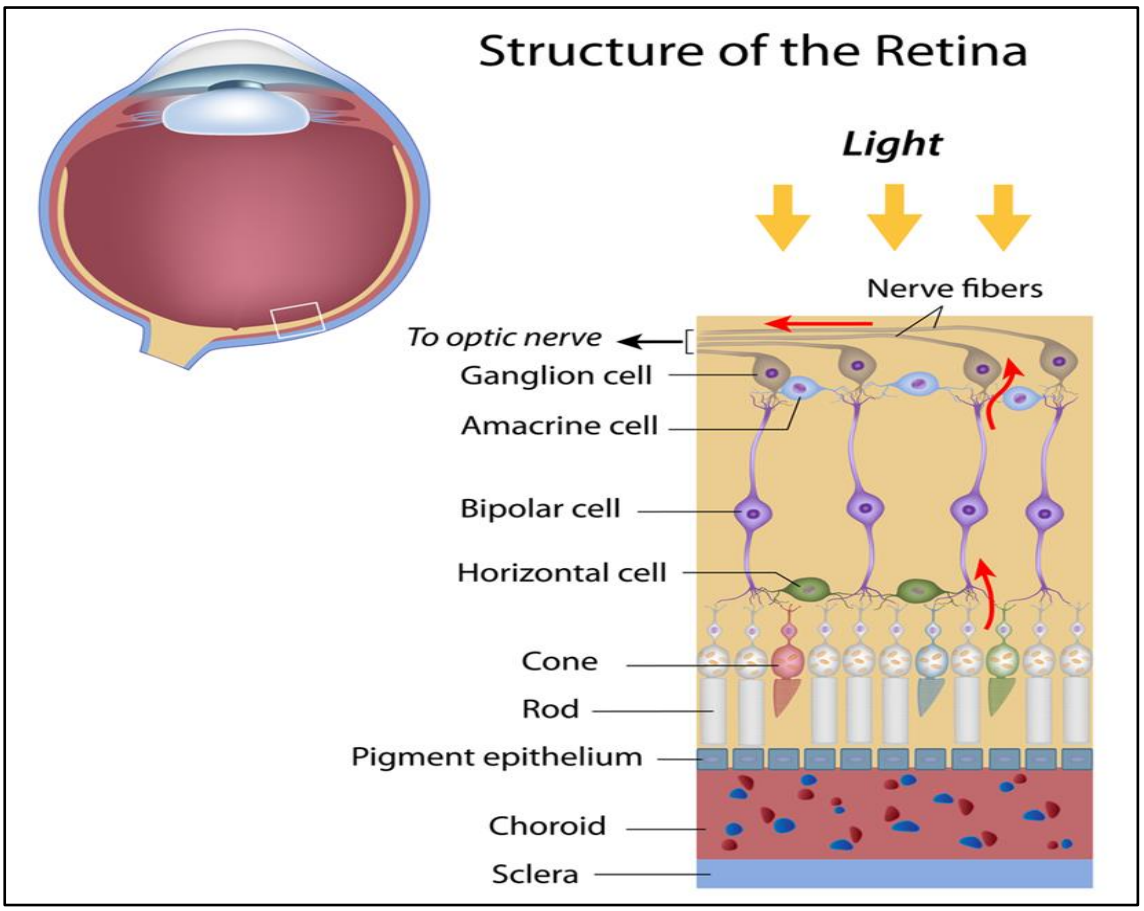
1. **Photoreceptors**:
   - **Rods**: Responsible for vision in dim light and peripheral vision (scotopic vision). They have high sensitivity to light but no color vision.
   - **Cones**: Responsible for color vision and sharp visual acuity (photopic vision). Sensitive to different wavelengths of light.
2. **Bipolar Cells**: These cells transmit electrical signals from photoreceptors to ganglion cells.
3. **Ganglion Cells**: Their axons form the optic nerve and transmit visual information to the brain.

4. **Horizontal cells/** transmit signals from rods and cones to bipolar cells, the main function is enhanced visual constant
5. **Amacrine cells /** help in temporal summation and in initial analysis of visual signals before leaving retina

Blood Supply of the Retina

The retina receives its blood supply from two sources:

1. **Central Retinal Artery**: Supplies the inner layers of the retina.
2. **Choroidal Circulation**: Supplies the outer layers of the retina, particularly the photoreceptors.



Retinal Functions

1. **Phototransduction** /Phototransduction is the process by which light is converted into electrical signals.
2. **Signal Transmission to the Brain /** The electrical signals from ganglion cells are transmitted through their axons (forming the optic nerve) to the **lateral geniculate nucleus (LGN)** of the thalamus.
3. **Visual Processing and Perception /** retina contributes to several aspects of vision
4. **Contrast Sensitivity**: The ability to detect differences in light intensity.
    a. **Color Vision**: Cones enable color perception by responding to different wavelengths of light.
    b. **Motion Detection**: Through the complex interaction between different retinal cells, motion can be detected by analyzing the changes in the light signals.
5. **Adaptation to Light /** The retina adapts to varying light conditions through two processes
    a. **Light Adaptation**: When transitioning from a dark environment to a light one, the retina adjusts by reducing the sensitivity of photoreceptors.
    b. **Dark Adaptation**: In low-light conditions, the retina increases sensitivity, especially through rod cells, which are more effective in dim light.

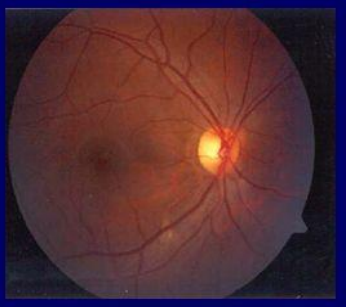
Macula

Macula / Macula Lutea

Small central area of retina (Located in centre of retina)

About 5 - 5.5 mm in diameter

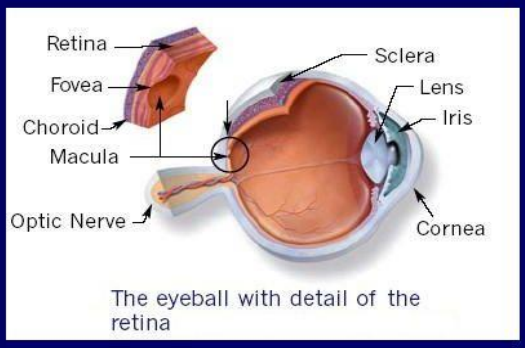
Responsible for central vision



Fovea

At the centre of macula

About 1.5 mm in diameter (the same as that of an average optic disc)

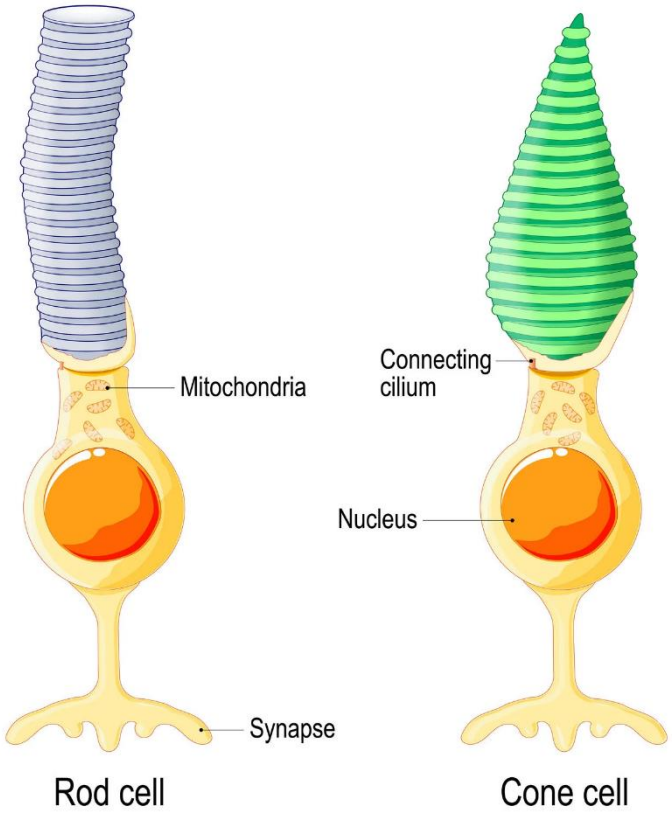


The eyeball with detail of the retina

Table 15.1 Comparison of Rods and Cones

Table 15.1 Comparison of Rods and Cones

RODS	CONES
Noncolor vision (one visual pigment)	Color vision (three visual pigments)
High sensitivity; function in dim light	Low sensitivity; function in bright light
Low acuity (many rods converge onto one ganglion cell)	High acuity (one cone per ganglion cell in fovea)
More numerous (20 rods for every cone)	Less numerous
Mostly in peripheral retina	Mostly in central retina


Mitochondria
Synapse
Rod cell
Connecting cilium
Nucleus
Cone cell